Water quality monitoring

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Figure 1:

STILL WATERS

The world-famous Venetian Lagoon is the focus of a new experiment in water quality monitoring

Water quality monitoring stations are an effective tool in understanding the state of the aquatic environment and a valuable support in planning its rehabilitation, as well as facilitating scientific analysis. Determining the physical-chemical parameters that characterize water is critical to understanding flora and fauna. Often linked to the delicate balance of their environment, they are considered accurate, trusty indicators of the state of the body of water.

Online water quality analysis instruments provide measures of level, conductance, pH, temperature, turbidity and dissolved oxygen. Other available measures include parts of the electromagnetic spectrum (light) that indicate absorption or scatter (chlorophyll, nitrate and fluorescence), together with ion-selective electrodes.

The use of sophisticated measurement techniques, for both portable and continuous monitoring, allows the collection of data that can be processed to obtain accurate profiling of the physical-chemical parameters. By focusing the analysis on continuous monitoring, it is possible to detect limits in this type of measure, mainly related to the biofilm accumulation (microfouling) on the probe's electrodes, potentially affecting the duration, quality and reliability of the measurements.

To test the response of multiparameter instrumentation, even in massive fouling conditions, the Molecular Sciences and Nanosystems department of Ca' Foscari University, Venice, has conducted a campaign lasting 14 months, using a probe manufactured by Nesa and specially developed for wide-range monitoring of both fresh and brackish water.

IDEAL TESTING ENVIRONMENT

The lagoon basin of Venice, known for its nitrogen-rich waters and therefore prone to heavy development of microorganisms, is an exceptional place to test instrumentation. It is also subject to multiple types of monitoring, both physical-chemical-biological and hydrological. Currently under construction is MOSE, a large-scale flood-prevention system designed to protect areas at risk during high tide events due to the combination of strong south winds, low atmospheric pressure and lunar phases.

In 2013 Ca' Foscari University launched a partnership with Venice's Centro Maree (Tides Center) and FPecoenergy, a specialist research company and distributor of Nesa's products for customized applications. Its aim

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Figure 1: The multiparametric probe at the moment of recovery

Figure 2: The biotic crust covering the probe, showing *Ascidians tunicates*, bivalve molluscs, polychaete annelids, barnacles and crustaceans

was to confirm whether the presence of microbial films and/or fouling made by water organisms could alter the sensors' sensitivity.

A standard WMP6 probe was chosen for measuring the water (up to a maximum depth of 20m), temperature, conductivity, pH, redox and dissolved oxygen. The probe was equipped with a Nesa Linux TMF100 multichannel datalogger (with a server on board), and measured parameters were transmitted to a dedicated website by an industrial modem GPRS.

The website featured a real-time alphanumeric graphical display giving daily, weekly and monthly historical data. IRIS web software was used to ensure a user-friendly interface and quick access to data.

HISTORICAL MONITORING SITE

The monitoring station was installed in the Punta della Dogana area, on the Grand Canal side, very close to the world-famous St Mark's Square. The location was chosen following careful evaluation and based on in-depth knowledge of the biological and physical-chemical characteristics of the lagoon. The multiparametric probe was installed here.

A few meters away, the Fondamenta Zattere Ai Saloni (a path along the Giudecca canal) hosts the historic marine monitoring station, built in 1923 by the Military Geographic Institute. This site has been adopted as a local reference for the city of Venice and the entire lagoon.

THE LAGOON BASIN OF VENICE IS KNOWN FOR ITS NITROGEN-RICH WATERS

The first data was collected between June 20 and October 15, 2014, with NESA's technicians providing onsite maintenance, and the probe was then removed from the water, cleaned and re-installed for a new series of measures. Researchers from the Molecular Sciences and Nanosystems department of Ca' Foscari University of Venice provided data series comparison between measurements acquired during the week prior to maintenance and the one immediately following it. The results showed the data before and after the maintenance to be comparable. The photographic and laboratory documentation highlighted a massive state of fouling on the probe, notably the presence of *Ascidians tunicates*, bivalve molluscs, polychaete annelids, barnacles and crustaceans. This did not, however, influence the standard of the data collected by the sensors, evidence of the quality of Nesa's WMP6 probe's materials, structure and functional features.

BASIS FOR ONGOING RESEARCH

After the first months of operation and maintenance, the probe continued to collect data for an annual measurement of the water parameters of the lagoon. The overall evaluation and comparison between this annual data forms the basis of joint research between professor Giampietro Ravagnan of the Molecular Sciences and Nanosystems department and the Centro Maree. The raw data was elaborated by Fausto Piranomonte of FPecoenergy, to allow further analysis.

Figure 5 shows the comparison of the dissolved oxygen and water temperature measurements carried out between August 2014 and August 2015. The influence of temperature on gas solubility in liquids was already known, since a temperature increase causes a fall in solubility. The analysis carried out on the data measured by the WMP6 probe confirmed this, and the difference of temperature and dissolved O_2 between the two years is very interesting. As a macroscopic sign of a tendency toward heating, it was a good reflection of the climate trend in 2015.

For the European sector (according to the NOAA National Centers for Environmental information), 2015 was the second hottest year on the mainland since the start of

Figure 4: Conclusion of clean-up operations and checking the multiparametric probe's functionality

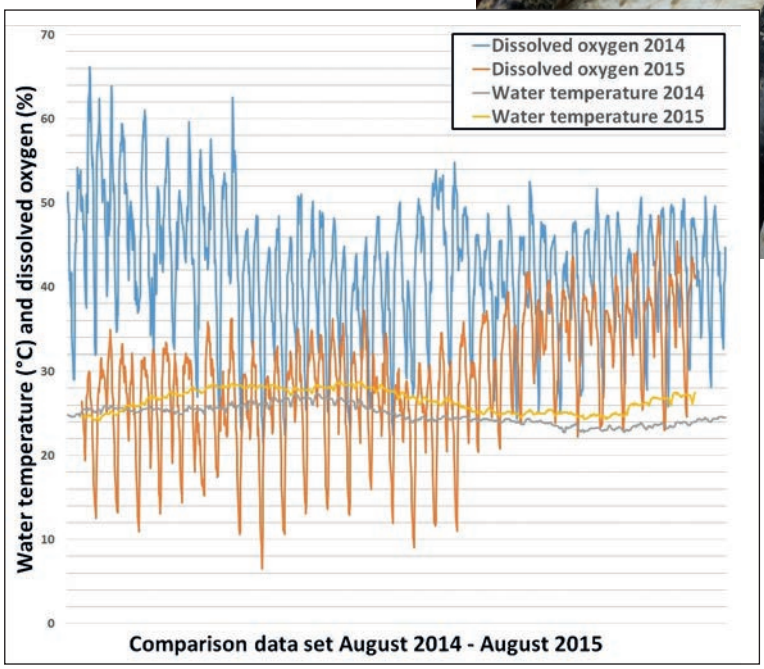

Figure 5: Comparison of disolved oxygen and water temperature between August 2014 and August 2015

"This European climate change, which is in line with the global tendency, has caused a net warming of the lagoon water in Venice"

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measurements. It showed a rise of 1.67°C over the preceding year, which showed an even greater rise over 2013 (1.73°C). This European climate change, which is in line with the global tendency, has caused a net warming of the lagoon water in Venice, a rather closed and shallow basin.

RISING WATER TEMPERATURE

This increase in temperature has led to a decrease in dissolved O_2, with all the biological implications, namely a growing tendency to anoxic phenomena (which occurs with the establishment in marine and ocean waters of environmental conditions characterized by extreme scarcity or absence of oxygen in the layers of water under the surface. It has also prompted the production of sulfur compounds and methanogenic compounds, which have a large greenhouse effect, shifting the balance of the gases in the water to the atmosphere, a phenomenon partly mitigated by the tidal variations. The real-time measurement of water parameters, even in the off-grid areas of the lagoon, could prevent the occurrence of environmental dystrophy phenomena by improving the circulation and/or removal of biomass which, with its degradation, adversely affect the trophic chains of fish and molluscs that play a key role in fixing CO_2.

THE VENICE LAGOON EXPERIMENT LASTED 14 MONTHS

FINAL RESULTS

The final result exceeded the expectations of both the Molecular Sciences and Nanosystems department and the Centro Maree. Although it is already considered good practice to conduct maintenance of submerged multiparametric probes at least every three months, the experience showed that NESA WMP6 probes also work well in critical conditions caused by fouling. The WMP6 can therefore be considered an absolutely effective instrument for monitoring brackish water, thanks to its stability and the potential for online transmission of real-time data via the embedded TMF Linux datalogger.

AC powered lights in the Venetian Lagoon have been replaced with 600 solar-powered LED lights. These lights indicate 22 channels in the lagoon, and a selection of them may be modified to allow them to host the WMP6.

NESA products feature very low power consumption and are normally powered by solar energy and a small backup battery, making them particularly well suited to outdoor use. As a result of its performance, the research team at the Molecular Sciences and Nanosystems department has recommended the WMP6 for implementation at monitoring stations, to provide online monitoring of large areas of lagoons and coastal marine environments. ▮

Acknowledgments:
Pictures taken during maintenance and cleaning of the probe are courtesy of Sabrina Manente, of the Molecular Sciences and Nanosystems department, Ca' Foscari University of Venice